

USE OF RC SHEAR WALLS IN STRENGTHENING OF MULTISTORIED BUILDING WITH SOFT STOREY AT DIFFERENT LEVEL

R. V. SURVE¹, Y. P. PAWAR², C. P. PISE³, S. S. KADAM⁴, D. S. JAGTAP⁵,
D. D. MOHITE⁶ & C. M. DESHMUKH⁷

¹Research Scholar, Department of Civil Engineering, SKN Sinhgad College of Engineering,
Korti, Pandharpur, Solapur, Maharashtra, India

²Assistant Professor, Department of Civil Engineering, SKN Sinhgad College of Engineering,
Pandharpur, Maharashtra, India

³Associate Professor & HOD, Department of Civil Engineering, SKN Sinhgad College of
Engineering, Korti, Pandharpur, Solapur, Maharashtra, India

ABSTRACT

Due to increasing population since the past few years car parking space for residential apartments in populated cities is a matter of major concern. Hence the trend has been to utilize the ground storey of the building itself for parking. Also for offices or for any other purpose such as intercourse hall etc. soft storeys at different levels of structure are constructed. Investigations of past and recent earthquake damage have illustrated that the building structures are vulnerable to severe damage or collapse during moderate to strong ground motion. An earthquake with a magnitude of six is capable of causing severe damages of engineered buildings, bridges, industrial and port facilities as well as giving rise to great economic losses. Experience in the past earthquake has shown that a building with discontinuity in the stiffness and mass subjected to concentration of forces and deformations at the point of discontinuity which may leads to the failure of members at the junction and collapse of building. Hence in this paper attempt has been made to study performance of a building with soft storey at different level along with at GL. The nonlinear static pushover analysis is carried out. The hinges formed in the basic models are seen at performance point and to increase the performance, when it is strengthened with shear walls. Then the result obtained for basic models and strengthened models are compared in the form of performance point and hinge formation pattern at performance point.

KEYWORDS: Soft Storey, Shear Wall, Nonlinear Static Push-Over Analysis, Plastic Hinges, Stiffness, Performance Point

INTRODUCTION

Now a day's reinforced-concrete framed structure in recent time has a special feature i.e. the ground storey is left open for the purpose of parking. Also upper storey is left open for the purpose of communication hall etc. Such buildings are often called soft storey buildings. Open ground storey system is being adopted in many buildings presently due to the advantage of open space to meet the economical and architectural demands. But these soft storey multistoried buildings are inherently vulnerable to collapse due to earthquake load. These soft storeys buildings are collapsed due to irregularities introduced in RC frame buildings. These irregularities are primarily due to uneven distribution of mass, strength and stiffness in both plans, elevation of the building. Discontinuities of frame member and masonry infill walls are common

causes of irregularities in RC frame building. The most common type of vertical irregularity observed in many countries including India is buildings without masonry infill walls in the ground storey of RC frame building, which is commonly termed as open ground storey RC building (1). Storey shears increase considerably after the addition of infill walls. After the addition of infill walls the building becomes stiff as compared to the bare frame structure, it will attract large amount of lateral forces as compared to the bare frame structure. Infill's alter the behaviour of building from predominant frame action to predominant truss action and carry the lateral seismic force as a compressive axial force along their diagonals (2). There is an urgent need to assess the seismic vulnerability of buildings in urban areas of India as an essential component of a comprehensive earthquake disaster risk management policy (3). According to IS 1893 part 1: 2002, a soft storey is one in which the lateral stiffness is less than 70 % of that in the storey above or less than 80 % of average lateral stiffness of the three storeys above. An extreme soft storey is one in which the lateral stiffness is less than 60 % of that in the storey above or less than 70 % of average lateral stiffness of the three storeys above (7).

Modelling and Analysis of Building

In this paper, for analytical study multistorey building is considered with soft storey at different level along with ground level. The building is modelled with infill wall using finite element software SAP2000 version 14.4.2 and non-linear static pushover analysis is performed on all building models. To improve the seismic performance of such buildings lateral load resisting element i.e. shear walls are used. Shear walls are provided at corner of building in L shaped to improve seismic performance of building (4).

Building Description

The study is carried out on reinforced concrete moment resisting G+12 storey buildings with soft storey at different levels. The plan of building is same for all models. Height of each storey is 3.2 m. The building has plan dimensions 20 m x 20 m as shown in "figure 1". In the analysis special RC moment-resisting frames (SMRF) is considered. Other relevant data is given as below.

- Size of Building: 20 m X 20 m
- Grade of concrete: M 25
- Grade of steel: Fe 415
- Floor to floor height: 3.2 m
- Plinth height above foundation: 2 m
- Parapet height: 1.5 m
- Slab thickness: 150 mm
- Wall thickness: 230 mm
- Size of columns: 600 mm x 600 mm
- Size of beam: 300 mm x 700 mm
- Live load on floor: 4 kN/m²

- Floor finishes: 1.5 kN/m^2
- Roof treatment: 1.5 kN/m^2
- Seismic zone: V
- Soil condition: Medium
- Importance factor: 1
- Density of concrete: 25 kN/m^3
- Density of masonry: 20 kN/m^3

Seismic Response of Soft Storey Building

Three models with soft storey at different levels are considered along with soft storey at ground level and these models with incorporation of shear walls are considered. Various models under consideration are:

Model I: G+12 storeys building with soft storey at GL and 4th floor without retrofitted with shear walls as shown in figure 2

Model II: G+12 storeys building with soft storey at GL and 8th floor without retrofitted with shear walls as shown in figure 3

Model III: G+12 storeys building with soft storey at GL and 12th floor without retrofitted with shear walls as shown in figure 4

Model IV: G+12 storeys building with soft storey at GL and 4th floor without retrofitted with shear walls as shown in figure 5

Model V: G+12 storeys building with soft storey at GL and 8th floor retrofitted with shear walls as shown in figure 6

Model VI: G+12 storeys building with soft storey at GL and 12th floor retrofitted with shear walls as shown in figure 7

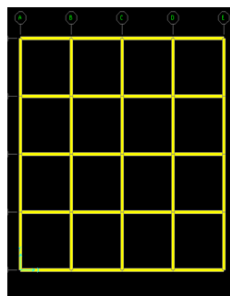
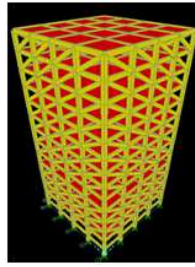
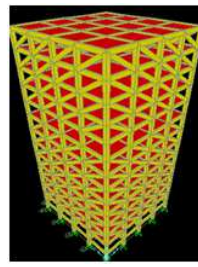


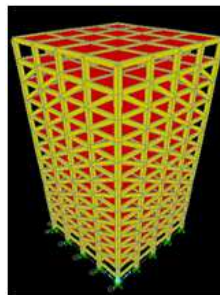
Figure 1: Plan of Building



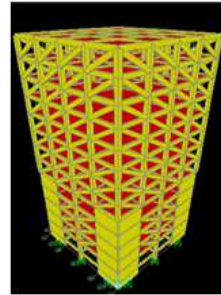
**Figure 2: G+12/GL& 4th floor
Soft Storey**



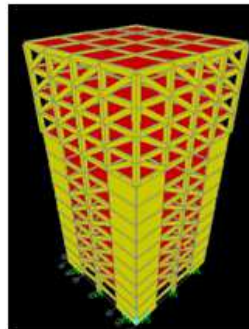
**Figure 3: G+12/GL&8th Floor
Soft Storey**



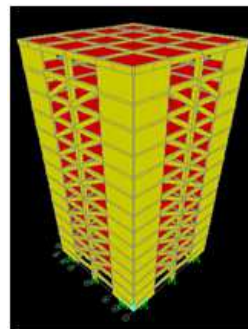
**Figure 4: G+12/GL& 12th Floor
Soft Storey**



**Figure 5: G+12/GL&4th Floor Retrofitted
with Shear Wall**



**Figure 6: G+12/GL& 8th Floor Retrofitted
with Shear Wall**



**Figure 7: G+12/GL& 12th Floor Retrofitted
with Shear Wall**

RESULT AND DISCUSSIONS

In the present study, non-linear response of RC frame high rise building with soft storey at different levels in addition to one at ground floor using SAP2000 under the loading has been carried out and the result are presented in terms of performance point and roof displacement.

Comparison of Performance of Various Frames

Pushover analyses of models with and without shear walls are carried out. Comparison between the performance point in terms of base shear and roof displacement obtained from the nonlinear static analysis and hinge formation pattern of the models without shear walls and with shear walls are done. Table 1 shows the performance point and roof displacement of models with and without shear walls.

Table 1: Performance Point and Performance Level for Model Without and with Shear Walls.

Description	Model Without Shear Walls	Model with Shear Walls
Soft Storey at GL & 4th Floor		
Performance point in X direction	5350.91kN,123mm	7273.72kN,93mm
Performance point in Y direction	5350.91kN,123mm	7273.72kN,93mm
Performance level	B-IO	B
Soft Storey at GL & 8th Floor		
Performance point in X direction	5606.61kN,125mm	8335kN,92mm
Performance point in Y direction	5606.61kN,125mm	8335kN,92mm
Performance level	B-IO	B
Soft Storey at GL & 12th Floor		
Performance point in X direction	5782.51kN,127mm	9248.39kN,91mm
Performance point in Y direction	5782.51kN,127mm	9248.39kN,91mm
Performance Level	B-IO	B

In above table (the 1st value is of Base Shear & 2nd value denotes Roof Displacement)it is clear that the performance level for the models without shear walls is within B-IO range. Though the performance level is within B-IO range, it is observed that hinges are formed in the columns of ground level sub storey. Hence retrofitting is carried out with shear walls. The performance level for the models with shear walls is linear and roof displacement of the retrofitted model is less as compare to models without shear walls. Also it is observed that hinges are not formed in the column of buildings with shear walls. Hence shear walls improves seismic performance of building.

Hinge Formation Pattern

Figure 8 to figure 10 show the hinge formation pattern in models without shear walls in X & Y direction respectively. From this it is clear that, due to the high shear forces at ground level soft storey; the hinges are formed in columns of ground soft storey. However it is observed that no hinges are formed in columns of ground soft storey, when retrofitted with shear walls.

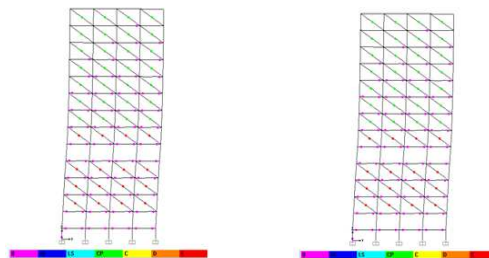


Figure 8: Hinge Formation at PP For G+12 Building with Gl & 4th Floor Soft Storey in X and Y Direction.

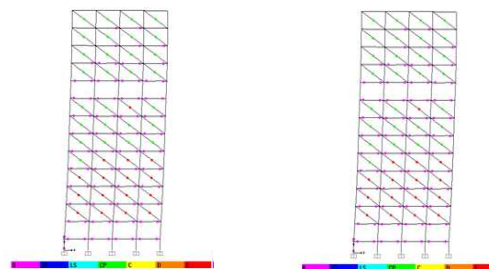


Figure 9: Hinge Formation at PP for G+12 Building with Gl & 8th Floor Soft Storey in X and Y Direction.

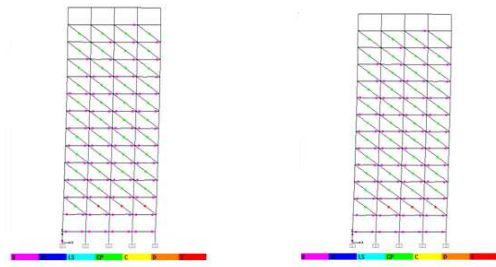
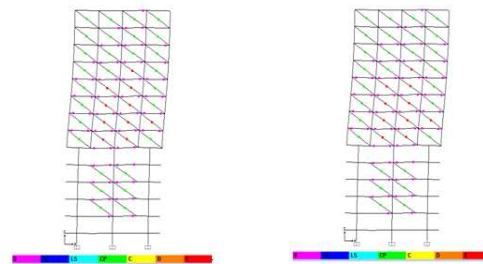
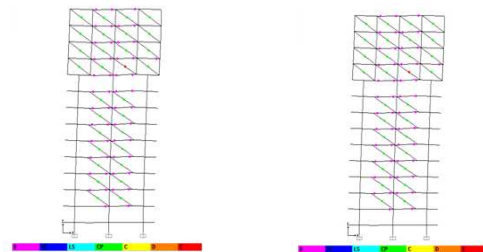


Figure 10: Hinge Formation at PP for G+12 Building with G1 & 12th Floor Soft Storey in X and Y Direction.

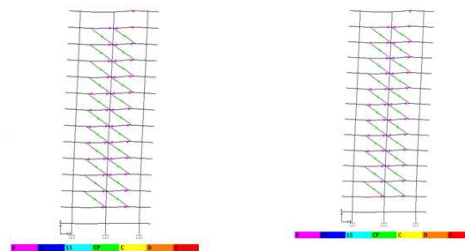
“Figure 11” to “figure 13” shows the hinge formation pattern in retrofitted models. From this hinges formation pattern, it is clear that no hinges are formed in bottom storey columns and the performance of the soft storey is improved.



**Figure 11: Hinge Formation at PP for G+12 building with G1 & 4th Floor
Retrofitted With Shear Wall In X And Y Direction**



**Figure 12: Hinge Formation at PP for G+12 Building with G1 & 8th Floor
Retrofitted With Shear Wall In X And Y Direction**



**Figure 13: Hinge Formation at PP for G+12 building with Ground & 12th Floor
Retrofitted with Shear Wall in X and Y Direction**

CONCLUSIONS

- The results obtained as seismic performance of G+12 RCC building with soft storey at different level along with soft storey at ground level are tragic.
- It is observed that plastic hinges are developed in columns of ground level soft storey which is not acceptable criteria for safe design.
- After retrofitting of all the models with shear walls hinges are not developed in any of the columns.
- Provision of shear walls results in reduction in lateral displacement.
- Displacement reduces when the soft storey is provided at higher level.
- After retrofitting the base shear carrying capacity is increased by 19.22 % to 34.64%.
- This study highlights as we shift soft storey to higher level yielding is less than the lower level soft storey and lower intensity hinges are formed.

REFERENCES

1. Rahiman G. Khan and Prof. M. R. Vyawahare (2013), Pushover analysis of tall building with soft storey's at different levels, International Journal of Engineering Research and Application, ISSN: 2248-9622, Vol.3, pp. 176-185.
2. Fardis M. N, Panagiotakos T. B., 1997, "Seismic Design And Response of Bare And Masonry Infilled Reinforced Concrete Buildings Part II: Infilled Structures", Journal of Earthquake Engineering, Imperial College Press, Vol. 1, No. 3, pp. 475-503.
3. Prof. Ravi Sinha and Prof. Alok Goyal, "A National Policy for Seismic Vulnerability Assessment of Buildings and Procedure for Rapid Visual Screening of Buildings for Potential Seismic Vulnerability", pp. 1-9.
4. S. I. Khan et al. (2013), Seismic evaluation and retrofitting of RC building by using energy dissipating devices, International Journal of Engineering Research and Applications, ISSN-2248-9622, Vol 3(3), pp. 1504- 1514.
5. FEMA 356, 2000, Prestandard and Commentary for the Seismic Rehabilitation of Buildings, Federal Emergency Management Agency, Washington, D. C.
6. ATC, NEHRP Guidelines for the Seismic Rehabilitation of Buildings, FEMA 273 Report, prepared by the Applied Technology Council for the Building Seismic Safety Council, published by the Federal Emergency Management Agency, Washington, D.C. 1997a.
7. IS 1893(PART-1):2002 Indian Standard Criteria for earthquake resistant design of structures.

